SUBMILLIMETER-WAVE MOMED MIXERS FOR EARTH AND PLANETARY REMOTE SENSING

Interim Report

JPL Task 1025

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A. OBJECTIVES

In recent years, a new-style device technology, MOMED (Monolithic Membrane Diode) was demonstrated to replace old QUID (Quartz Upside-down Integrated Diode) by our team at JPL. The objective of this project is to analyze, design, fabricate, and demonstrate a 557 GHz fundamental mixer (heterodyne downconverter), based on MOMED technology, which can cover 530-595 GHz with a minimum instantaneous IF (intermediate frequency) bandwidth of 3 GHz. Replacing the QUID technology with MOMED process will substantially improve the repeatability, sensitivity, reliability, and performance of the final circuit. Specific sensitivity goals are <1500 K double sideband (DSB) for the downconverters with local oscillator (LO) power requirements below 3 mW. If successful, the same technology can be applied to 200, 400, 600 GHz receivers MLS (Microwave Limb Sounder), 500-600 GHz receivers for SIGNAL (a proposed Mars Scout mission) and VESPER (Venus Sounder), or future channels on SWCIR (Submillimeter Wave Cloud Ice Sounder) at 900 and 1200 GHz.

B. PROGRESS AND RESULTS

1. Science Data

The first stage of the work focused on the use of analytic tools for the design of the mixer device, the embedding circuitry and the feed horn. The mixer diode was modeled from the device parameters, including the semiconductor doping level and the anode size (see Figure 1). The analytical results suggest the design can achieve a DSB noise temperature of approximately 1000 K with between 7 and 8 dB of conversion loss (not including circuit losses expected to be about 0.5 dB) using an LO power level of about 1 mW (at the diode).

Next, the passive embedding structure (see Figure 2), including the microstrip filter (for signal separation) and a broadband waveguide coupling probe, was analyzed. The circuit parameters were optimized to match the diode operating impedance in order to achieve the desired RF bandwidth (530-595 GHz) while maximizing the IF bandwidth of the mixer.

Simulations of the mixer circuit, which were performed with variations on the LO drive level, the diode size and the semiconductor doping level, have given us the information necessary for effectively laying out a device mask design encompassing an appropriate array of variations to efficiently hone in on the best device design during the empirical phase of this task.

An input waveguide corrugated feed horn was separately designed analytically to achieve low sidelobe levels and E/H plane symmetry across the broad bandwidth of operation. The feedhorn is attached separately to the mixer block during testing.

2. Other Results

Wafer material has been purchased for use in the fabrication of the mixer devices. Planned activities for the final year of this DRDF effort include:

(a) Generation of a device mask set, including variations on anode size, diode finger length, transmission line matching circuitry and beam lead placement.
(b) Fabrication of devices and mounting structures.
(c) Fabrication of feedhorns
(d) Assembly and test of mixers.
(e) Iteration on design, if time permits.

C. SIGNIFICANCE OF RESULTS

Thus far, this task has developed a design for a broadband fundamental mixer, operating at a center frequency of 557 GHz with a DSB noise temperature of about 1000 K with low LO power requirements. This represents a significant improvement (by approximately a factor of 2) over the noise performance of the subharmonic QUID-style mixers at similar frequencies previously made for the MIRO (Microwave Imager for Rosetta Orbiter) and EOS-MLS (Earth Observing System Microwave Limb Sounder) instruments at JPL.

The sensitivity of these mixers can allow for much shorter spectral line observation times, as well as the detection and characterization of weaker lines. The large observational bandwidth of the mixer can allow for a single receiver to measure many more spectral lines. This can lead to a less complex, less costly instrument by requiring fewer distinct receiver systems.

D. FINANCIAL STATUS

The total funding for this task was $274,000.00, of which $96,489.69 has been expended.

E. PERSONNEL

In addition to the personnel listed at the top of this report, Erich Schlecht of the Microwave and Lidar Technology section (386) participated in the design of the mixer, and Aluizio Prata of section 336 participated in the design of the feed horn.

F. PUBLICATIONS

None.

G. REFERENCES

[1] P.H. Siegel, R.P. Smith, S. Martin and M. Gaidis, "2.5 THz GaAs Monolithic Membrane-Diode Mixer," IEEE Trans. Microwave Theory and Tech., v. 47, no. 5, May 1999, pp. 596-604.

[2] Michael C. Gaidis, H.M. Pickett, C.D. Smith, R.P. Smith, S.C. Martin and P.H. Siegel, "A 2.5 THz Receiver Front-End for Spaceborne Applications," IEEE Transactions Microwave Theory and Techniques, MTT-48, no. 4, April 2000, 733-739.

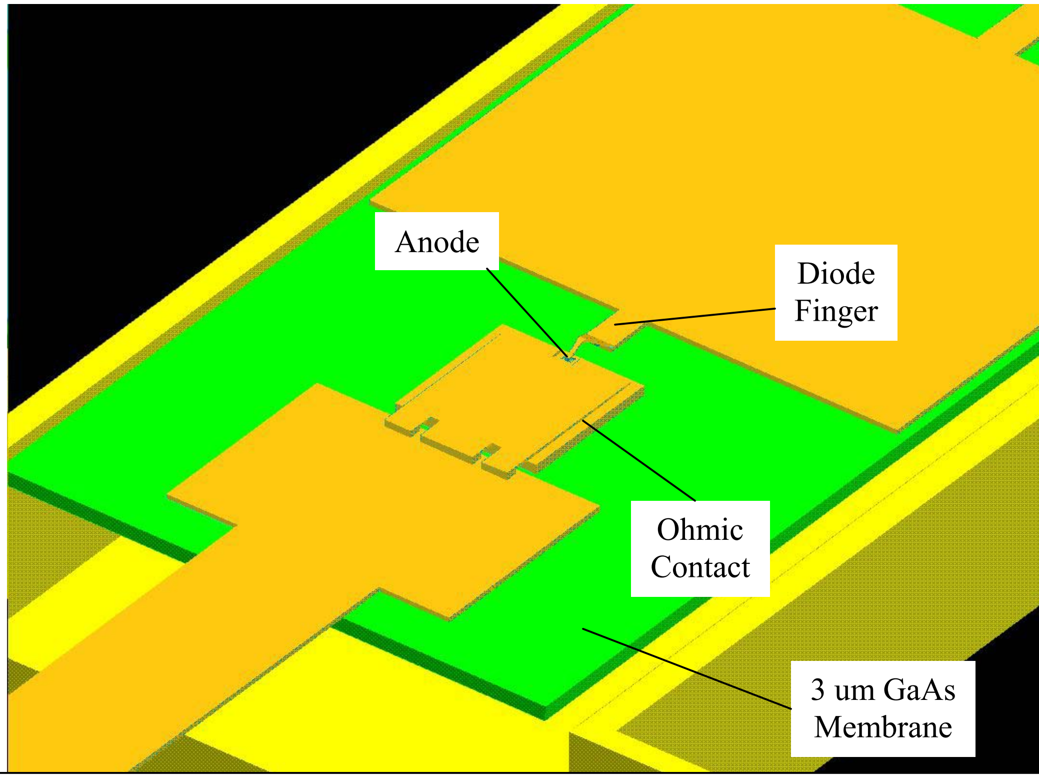

Figure 1: MOMED mixer diode.

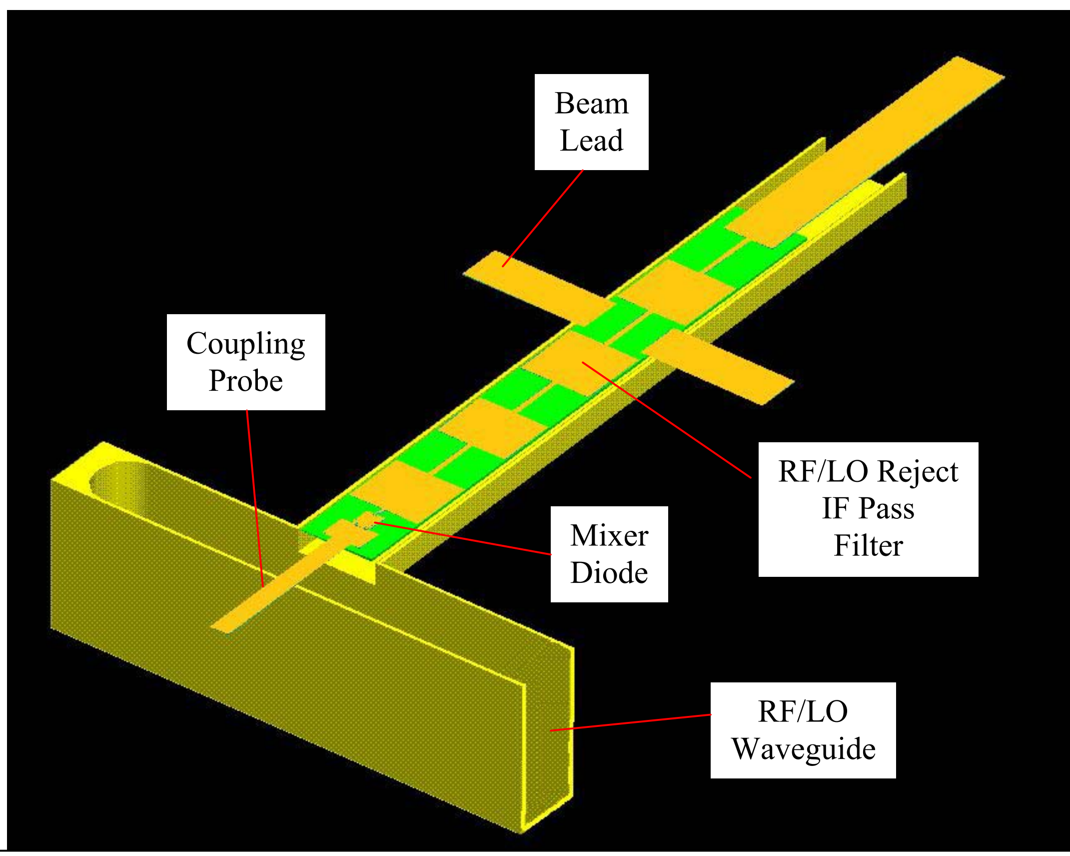

Figure 2: Complete mixer circuit, including device and passive embedding structure.